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ABSTRACT

Infants judged to be at risk for subnormal intellectual growth were randomly assigned to an experimental (N=27) or a control (N=25) group. Infants in both groups received medical care and dietary supplements; their families received social work services on a request basis. Experimental children participated in an educational day care program beginning before the third month of life. The day care program was composed, in part, of curriculum activities designed to stimulate intellectual growth. Between 6 and 36 months of age, experimental children maintained normal intellectual growth; control children declined in IQ beginning between 12 and 18 months of age and remained significantly lower than experimental children at 24 and 36 months. The mother-child IQ correlation for control dyads was .43; for experimental dyads the correlation was -.05. These two types of evidence are interpreted as support for the importance of early environments in the development of intelligence. (Author/RH)

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The Modification of Intelligence through Early Experience

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Running Head: Early Experience

Abstract

Infants judged to be at risk for subnormal intellectual growth were randomly assigned to an Experimental (N = 27) or a Control (N = 25) group. Infants in both groups received medical care and dietary supplements; their families received social work services on a request basis. Experimental children participated in an educational day care program beginning before the third month of life. The day care program was composed, in part, of curriculum activities designed to stimulate intellectual growth. Between 6 and 36 months of age, Experimental children maintained normal intellectual growth; Control children declined in IQ beginning between 12 and 18 months of age and remained significantly lower than Experimental children at 24 and 36 months. The mother-child IQ correlation for Control dyads was .43; for Experimental dyads the correlation was -.05. These two types of evidence are interpreted as support for the importance of early environments in the development of intelligence.

The Modification of Intelligence through Early Experience

In the past two decades, preschool intervention programs have been implemented to better prepare children from low-income families for public schooling. The rationale for these programs has been drawn from evidence suggesting that the early experiences of children are important in determining subsequent development (Hunt, 1961). Intervention programs are thought to be needed because children from low-income families are disproportionately judged as failing in school (Coleman, 1966; Jensen, 1969; Mosteller & Moynihan, 1972), and because school failure is thought to be negatively associated with later contributions to society (Owen, 1974; Gallagher, Haskins, & Farran, in press).

The preschool intervention programs that began in the 1960s, which included Headstart and the small scale experimental programs that preceded Headstart (e.g., Gray & Klaus, 1965; Weikart, Bond, & McNeil, 1978), typically enrolled children who were 3 or 4 years of age, and attempted to teach them academic skills and concepts considered important for school success. Evaluations of these programs have consistently shown two results. First, after a year or two of preschool education, these children from economically poor families exhibited IQ's that were approximately 8-10 points higher than controls who did not receive intervention. Second, within a year or two after entry into the public schools, Experimental children were not superior to Control children in either IQ scores or achievement test scores (Bronfenbrenner, 1975; Cicirelli, 1969; Haskins, Finkelstein, & Stedman, 1978; Rivlin, 1978; White, 1973).

Partially as a result of these early findings, educators intensified the arguments that early experience was critical to intellectual development, that children from low-income families were already too far behind by the age of 3 or 4 to profit maximally from preschool education, and that earlier intervention might produce larger and more permanent gains in intellectual development. A logical outcome of this perspective was an emphasis on intervention programs that began in earliest infancy. Of the many such programs that were attempted at the beginning of this decade, two have enrolled infants within the first half-year of life, included a control group, documented their center-based intervention, kept standardized test data, and published their results (Garber & Heber, 1977; Heber & Garber, 1973; Ramey, Collier, Sparling, Loda, Campbell, Ingram, & Finkelstein, 1976; Ramey & Campbell, 1979; Ramey & Haskins, in press). In this paper, we present results concerning the development of intelligence from one of these two programs.

More specifically, two types of data analyses are reported here. First, a comparison of standardized intelligence test performance by Experimental and Control children is reported. As part of this comparison, we examine the trends in IQ development by both groups of infants with particular attention to the cumulative deficit hypothesis. As Jensen (1974) has noted:

> ...cumulative deficit stands both for the purported phenomenon of an increasing decrement in test scores with increasing age of disadvantaged children relative to advantaged children, and for the hypothesis which explains this phenomenon in terms of the cumulative effects of a deprived environment (p. 996).

In reporting the results of an experiment failing to support the cumulative deficit hypothesis in school-aged children, Jensen (1974) concluded by noting that:

> ...the prevailing general acceptance of the cumulative deficit hypothesis as an explanation for the generally lower IQ of Negroes as compared with Whites remains unsupported by any methodologically sound evidence in the literature. The results of the present study, in addition to the lack of contradictory evidence in the previous research literature, suggest that the causes of the Negro IQ deficit, whatever they might be, are not reflected in age decrements beyond about age 5 but appear largely to involve factors whose influences are already established before school age (p. 1018).

Data reported in this paper will explore the cumulative deficit hypothesis during the years before age 5.

Second, we present mother-child IQ correlations for Experimental and Control children. There is wide agreement from empirical findings that the single parent-offspring correlation in intelligence is about .5 (Erlenmeyer-Kimling & Jarvik, 1963; McClearn & DeFries, 1973). The polygenetic model of intelligence predicts this finding on the basis that offspring receive one-half their genes from each parent. Since intelligence is believed by many investigators to be a polygenetic trait, on the average, children will also share about half their genes for intelligence with each parent (Scarr-Salapatek, 1975). Strickberger (1968) has shown mathematically that this polygenetic assumption leads to a predicted single parent-offspring correlation of about .5. The environmental model of intellectual growth also predicts a positive correlation between mother and child IQ although the model is apparently silent with regard to specifying a particular value for this

correlation (Urbach, 1974). The basis for the correlation predicted by environmentalists is that mothers provide a substantial portion of the infant and young child's environment, that the quality of stimulation provided by mothers is directly related to children's intelligence, and that this stimulation has a substantial impact on the child's intellectual growth.[1]

In the program to be described in this report, mothers and Experimental infants were separated for a substantial portion of the day during the infant's first 3 years of life; Control infants were reared primarily by their mothers, assisted in some cases by other relatives. The polygenetic model would predict identical mother-child IQ correlations of .5 for both Experimental and Control mother-infants dyads because the intervention program in no way influenced the mothers' genetic contribution to their offsprings' IQ. By contrast, the environmental model would predict a higher correlation among Control than Experimental dyads because Control infants were reared primarily in an environment provided by their mother or a close relative while Experimental infants were reared, at least partially, in an environment that was created independently of their mother's IQ.

Method

Subjects

Families were referred for this experiment through local hospitals, clinics, the County Department of Social Services, and other community agencies. Once families had been identified as potentially eligible, a staff member visited them at home to explain the program and to determine

whether they appeared to meet selection criteria. If so, mothers were invited to participate in further assessments.

During these assessments, which typically occurred in the last trimester of pregnancy, mothers provided demographic information about themselves and their family. In addition, their intelligence was assessed using the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955).[2] Criteria for selection included maternal IQ, family income, parent education, intactness of family, and nine other social factors that were weighted and combined to yield a single score called the High Risk Index (see Ramey & Smith, 1977 for details). Only families at or above a predetermined cutoff score were considered eligible.

Families have been admitted to the project at approximately 15-month intervals in four cohorts of about 28 each; there is an 8- to 10-month range between the oldest and youngest infant in each cohort. Half the families in each cohort were randomly assigned to the Experimental or Control groups. Although four cohorts have been admitted to date, infants in only two cohorts have reached the age of 36 months. Data presented in this paper are drawn from these first two cohorts admitted between 1972 and 1974.

A total of 60 families were offered the Experimental or Control programs in these first two cohorts; one family had previously refused the condition of random assignment to groups. Two families assigned to the Experimental group withdrew from the study immediately after assignment because they wanted to rear their infant exclusively at home. One Control mother withdrew her infant after a few months and before the infant was

tested because she wanted to be in the Experimental group. Thus, the potential sample of 60 eligible families was reduced to 57 before the experiment began. This represents an initial acceptance rate of 95%. In addition to the three infants who were withdrawn from the sample, three infants died (one Experimental infant at 3 months--diagnosed as a Crib Death at home, one Control infant of cardiomyopathy and seizure disorder of unknown etiology at 3 months, and a second Control infant of cardiac arrest at 18 months). The remainder of sample attrition was accounted for by one Control family who moved from the state, and one Experimental child who was diagnosed at 24 months as having nonprogressive encephalopathy with associated seizure disorder. Thus, of the actively enrolled sample of 57, data from 52 infants (91.2%), 27 in the Experimental group and 25 in the Control group, were still being obtained regularly when children were 36 months of age.

Insert Table 1 about here

Table 1 presents several demographic characteristics of the Experimental and Control groups. These data demonstrate the meager earned income, the low formal education, the high proportion of female-headed families, and the low level of IQ test performance by mothers in both groups.

Control and Experimental Programs

The primary difference between Control and Experimental programs was that Experimental children attended an educational day care program designed to help them maintain normal intellectual development. In order

to control some of the variables that may confound the experimental test of educational day care, we provided a number of services for both Experimental and Control families. First, because infants and children attending the day care center received excellent nutrition, we supplied iron-fortified Similac to Control families during the first 15 months of life. Second, we either provided pediatric care for families or arranged care through local clinics. Third, participants were given family support social services on a request basis. Fourth, mothers and infants from both groups participated equally in the program of standardized testing. In combination with random assignment to groups, these attempts to equalize potentially confounding conditions were designed to insure that the primary difference between the two groups was the educational day care program.

Day Care Program

The educational and service program developed for this project has been described in detail elsewhere (Ramey, et al., 1976; Ramey & Campbell, 1979; Ramey & Haskins, in press). Thus, only a brief characterization of the program will be presented here.

Physical setting. Children attended the nursery and toddler programs in a large building which also contains a public school kindergarten and a first grade classroom as well as the administrative and research staff of a child development center. Infants were cared for in a nursery on a different floor than the toddlers until about 13 to 15 months of age. Once infants could walk well and were judged to be socially ready by their teachers, they were transferred to the toddler program on a different floor where they were cared for until 3 years of age.

Teaching staff. A teacher-infant ratio of 1:3 was maintained in the nursery; a ratio of 1:4 or 5 was maintained in the toddler program. The nursery was organized to promote contacts between all teachers and all infants, with the exception that every two weeks a particular teacher was designated as responsible for a particular infant's educational curriculum. In the toddler program, each class of 8 to 10 children had two teachers. Lead teachers had training in early childhood education and previous experience as a preschool or elementary school teacher. The second teacher in each group was a teacher's aide, often working to obtain the Child Development Associates Certificate.

Attendance. Experimental infants began attending the day care program between 6 and 12 weeks of age. Some children arrived at the Center as early as 7:15; all were there by 9:15. Children began leaving at about 3:30; all were gone by 5:15. The Center was open five days per week, 50 weeks per year, and transportation was provided to ensure daily attendance.

Curriculum development. The nature of the experimental treatment is partially described by approximately 300 curriculum activities for children 0 to 36 months that were developed during the first three years of this program (Sparling, 1975; Sparling & Lewis, 1978). The framework for generating materials and activities in the curriculum is based on four sources: a) Piagetian developmental theory; b) previously established developmental milestones such as those observed by Gesell (1940); c) parents' statements about what they hoped their child would be capable of doing at a given age; and d) adaptive sets, such as task orientation, that may facilitate a child's learning of subsequent material.

Based on these sources, each curriculum item was developed to include an objective, specification of needed materials, behavior of the teacher, and expected outcome behavior of the child. The item was then assigned to a teacher who tried it out with particular infants. Next, teachers evaluated the adequacy of the item (clarity of goal, ease of administration, and child attentiveness). On the basis of this evaluation, items were modified or eliminated. About one-third of the items were also evaluated by an outside observer who watched teachers use the item on a number of occasions.

As items were developed and tested, they became part of a pool of items that were used routinely by teachers planning the educational program for individual infants and toddlers.

Standardized Test Administration

As mentioned previously, mothers were given a WAIS at the time they were interviewed for the program. Infants were tested with the Bayley Scales of Infant Development (Bayley, 1969) at 6, 9, 12, and 18 months of age; both the Mental Development Index (MDI) and Psychomotor Development Index (PDI) were administered on each occasion. At 24 and 36 months, children were given the Stanford-Binet Intelligence Scale (Terman & Merrill, 1973). Mothers, or in a few cases grandmothers or aunts, were always present during assessments. Bayley Scales were administered by five female testers; Binets by ten female testers. Assignment of testers to children was performed more or less at random depending on who was available at a given time.

Results

Group Differences

Changes between 6 and 36 months in Bayley MDI and PDI and Binet IQ scores for the two groups are given in Table 2; Bayley MDI and Binet IQ scores are plotted graphically in Figure 1.[3] These data were analyzed in two steps. Bayley MDI and PDI scores were analyzed separately in a 2 (groups) x

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Insert Table 2 about here

Insert Figure 1 about here

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4 (occasions) design using the multivariate-analysis-of-variance approach to repeated measures (McCall & Appelbaum, 1973). The occasions factor was represented by linear and quadratic trends. Because tests were not administered at equal intervals, orthogonal polynomial coefficients consistent with the metric of test administration were used. Based on the view that a low-income environment would produce a decline in test scores, particularly once verbal items became important, we predicted a groups × occasions interaction such that MDI scores of Control infants would decline while scores of Experimental infants would remain at or near average. Because the curriculum did not particularly focus on motor activities, we made no predictions for PDI scores. Significant interactions were further analyzed by t-tests on scores at each test occasion.

Binet results at 24 and 36 months were analyzed in a 2 (groups) x 2 (occasions) design, again by means of the McCall-Appelbaum (1973) approach to repeated measures.

Bayley MDI and PDI performance. As shown in Table 3, analysis of MDI data revealed a significant multivariate groups x occasions interaction. Both the

Insert Table 3 about here

linear and quadratic trends were significant components of the interaction. From the first panel of Figure 1, it appears that the interaction is acccounted for by a decrease in the Control group MDI from 6 to 18 months as contrasted with stable scores by Experimental infants over the same period.

That the trend difference between Experimentals and Controls was due to a decline in Control group scores between 12 and 18 months is confirmed by t-tests of scores for the two groups at each test occasion. None of the comparisons before 18 months was significant, ts $(49) < 0.77$, $ps > .44$, but the 18 months comparison was significant, t $(49) = 3.21$, $p < .002$. These results confirm the trend analysis presented above by demonstrating that significant IQ differences between Experimental and Control infants did not emerge until 18 months of age.

Results for the Bayley PDI are quite different than those obtained for the MDI (see Tables 2 and 3). Neither the groups x occasions interaction nor the main effect for groups were significant. However, the multivariate test of occasions was significant. Both the linear and quadratic components of this trend were significant. These effects revealed a decline in PDI scores between 6 and 18 months for both groups, from about 101 to 97. Thus,

in contrast to MDI performance, Experimental and Control group infants did not differ on PDI performance, both groups declining from slightly above average to slightly below average between 6 and 18 months.

Binet performance. Analysis of variance of the Binet data demonstrated a significant groups effect, F (1, 50) = 14.18, $p < .001$, but neither a significant groups x occasions interaction nor a main effect for occasions. Thus, as can be seen in the second panel of Figure 1, Experimental children demonstrated significantly higher scores than Control children at both 24 and 36 months on the Binet.

Effects of Day Care on Mother-Child IQ Correlations

The mother-child Pearson correlation for the 27 Experimental dyads, using children's Binet IQ at 36 months, was -.05; that for the 25 Control dyads was .43. By Z-test, the Experimental group correlation is not significantly different than 0, but is significantly different than .5 ($p < .05$). On the other hand, the Control group correlation is significantly different than 0 ($p < .05$), but not significantly different than .5. Thus, the Control group, but not Experimental group, correlation conforms to the value of .5 predicted by the genetic model of intelligence.

Discussion

This study has demonstrated that educational day care beginning before 3 months of age results in normal intellectual development, at least until 36 months of age, for children from high-risk families. By contrast, similar children not attending educational day care demonstrated a relative decline in IQ. Further, day care appeared to reduce the magnitude of mother-child resemblance in IQ at 3 years of age--an age from which Bloom (1964) has shown IQ tests to

predict adult IQ. A brief discussion of these findings will provide the groundwork for two conclusions, one concerning theories of intellectual development and one concerning intervention programs for children from low-income families.

Taken together, the findings reported here indicate that early experience has a substantial impact on intellectual development during the preschool years. Experimental children had significantly higher IQs than Control children, and this difference appeared to result from a decline in IQ by Control infants between 12 and 18 months. Relative to Experimental children, Control children demonstrated low IQs at both 24 and 36 months of age. This finding may indicate a stabilizing of Control group IQ at relatively low levels.

This finding appears consistent with Jensen's (1974) suggestion that evidence pertinent to the cumulative deficit hypothesis might have to be collected before age 5. The evidence reported here implies that IQ development of children from low-income families does not conform to that predicted by the cumulative deficit hypothesis--at least not in the sense that Klineberg (1963) meant when he invoked the compound interest analogy. Rather, we speculate that there are key intellectual deficits that occur in intellectually nonsupportive environments at times of rapid transitions in developmental processes. Because the 12- to 18-month period of development is a time of rapid language development, it is likely that future research on causes of intellectual deficits in children from low-income families might profitably focus on linguistic development during this transition period.

In any event, the primary effect of the educational day care program on group performance was to insure normal intellectual development throughout the first 3 years of life, while the environments of Control children seemed to be

associated with declines in intellectual development. It appears likely that enrollment in the intervention program could have prevented these declines.

Mother-child IQ correlations lend further support to the importance of environmental influences in accounting for intellectual development during the first 3 years of life. Control children, reared primarily at home or by close relatives, demonstrated a mother-child IQ correlation that was approximately what would be predicted by the genetic model of intellectual development (McAskie & Clarke, 1976). By contrast, Experimental children who had significant exposure to a day care environment that was independent of their mother's intellectual characteristics demonstrated mother-child IQ correlations that were not different than zero. These data are consistent with the hypothesis that when mothers provide half the infant's genes and a substantial part of the infant's environment, one can predict a significant relation between the mother's and child's IQ, but when the mother provides half the child's genes and a relatively moderate part of the young child's environment, one cannot necessarily predict a relation between the mother's and child's IQ.

These results concerning normal intellectual development by children from low-income families attending educational day care, declines in intelligence by children from low-income families reared at home, and lack of mother-child IQ correlation in day-care-attending children, demonstrate that the quality of early experience can have a substantial influence on intellectual development during the first 3 years of life. This finding is not to deny the importance of genetic influences on intellectual development. Even the most radical estimates of heritability leave some room for environmental influence (Burt, 1958; Jensen, 1969, 1973), thereby indicating that environmental influences must be considered. The results of this experiment do indicate, however, that

the degree of environmental influences can be quite substantial in some environments, and that this influence is, under some circumstances, independent of genetic influences as represented by the mother's IQ.

This experiment also suggests that under some circumstances early stimulation of the type provided by planned intervention programs can move high-risk children away from intellectual subnormality, thought by many to originate from genetic causes (Burt, 1958; Herrnstein, 1971; Jensen, 1969) toward average intelligence. This conclusion fits well with previous studies of what Bronfenbrenner (1975) has called "ecological" intervention. Thus, in studies such as this one that employed substantial environmental manipulations, the effect on mean levels of IQ performance have been impressive. This generalization applies to Skeels' (1966) adoption study of children who were retarded as infants, to Garber and Heber's (1977) early intervention study, and to Scarr and Weinberg's (1976, 1977) study of transracial adoptions. Thus, the primary issues for early intervention aimed at insuring average intellectual growth among children from low-income families would now appear to be, not whether intervention can be beneficial, but rather, what types of intervention are most useful for what types of children.

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Footnotes

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[1]Recent empirical support for the influence of maternal behavior on intellectual development, based on prospective longitudinal data, has been offered by Ramey, Farran, and Campbell (in press).

[2]Five mothers were less than 16 years old and were therefore given the Wechsler Intelligence Scale for Children (WISC: Wechsler, 1949).

[3]One infant in the Experimental group missed the Bayley testing at 6 and 9 months of age. This subject, therefore, could not be included in the longitudinal analyses. Thus, for the longitudinal analyses, the *Ns* for Experimental and Control groups were 26 and 25 respectively.

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Table 1

Demographic Data by Group

Group	N	Female Headed Family	Mean Earned Income in Year of Birth	Mean Number of Siblings at 36 Months	Mean Maternal Education at Child's Birth	Mean Maternal IQ
Experimental	27	78%	$2,333	0.81	10.30	82.63
Congrol	25	56%	2,400	1.16	10.08	81.36

Table 2

Means and Standard Deviations of Bayley Mental Development Index, Bayley Psychomotor Development Index, and Binet IQ for Experimental and Control Groups

Bayley Mental Development Index

	6		9		12		18	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Experimental	105.58	18.31	106.31	15.08	106.54	17.13	102.42	16.01
Control	102.24	11.63	103.96	15.07	105.48	14.34	89.08	13.49

Bayley Psychomotor Development Index

Experimental	102.04	12.93	99.77	16.89	106.15	13.81	95.35	10.04
Control	100.04	11.64	103.44	13.77	102.08	12.03	98.16	12.02

Binet IQ

	24		36	
	$\bar{X}$	SD	$\bar{X}$	SD
Experimental	92.58	11.19	95.15	14.42
Control	83.96	8.57	80.60	14.87

Note. Ns = 26 in Experimental group and 25 in Control group (see Footnote 3) for Bayley scores; 27 Experimental and 25 Control for Binet scores.

Table 3

MANOVA Summary Table of Bayley MDI and PDI Scores

Between 6 and 18 Months

Effect	df	F	p <
Bayley MDI			
Groups x Occasions			
MULT	2, 48	3.39	.04
Linear	1, 49	4.53	.04
Quadratic	1, 49	3.93	.05
Occasions			
MULT	2, 48	9.46	.001
Linear	1, 49	12.08	.001
Quadratic	1, 49	11.50	.001
Groups	1, 49	2.35	.13
Bayley PDI			
Groups x Occasions			
MULT	2, 48	0.40	.67
Linear	1, 49	0.56	.46
Quadratic	1, 49	0.25	.62
Occasions			
MULT	2, 48	6.30	.004
Linear	1, 49	5.33	.025
Quadratic	1, 49	7.32	.009
Groups	1, 49	0.00	.97

Figure Caption

Figure 1. Bayley MDI and Binet IQ scores for Experimental and Control infants between 6 and 36 months of age.

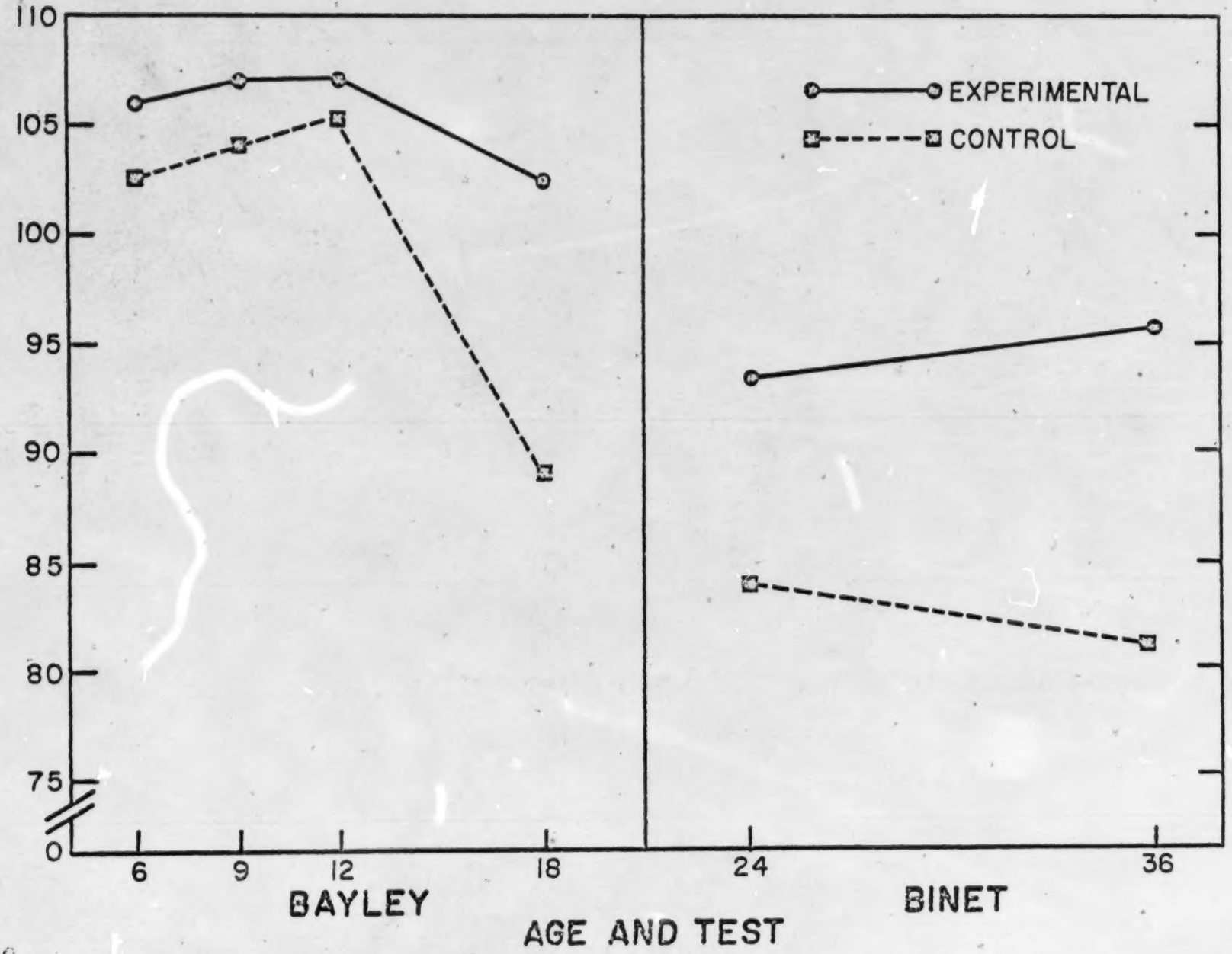
110
105
100
95
90
85
80
75
0
6
9
12
18
24
36
BAYLEY
BINET
AGE AND TEST
EXPERIMENTAL
CONTROL

Fig. 1.